

# **AIR MONITORING PLAN**

## **SITE PREPARATION AND MATERIAL REMOVAL**

### **FINAL DESIGN ENVIRO-CHEM SUPERFUND SITE ZIONSVILLE, INDIANA**

**Prepared For:  
ENVIRONMENTAL CONSERVATION AND  
CHEMICAL CORPORATION TRUST**

**Prepared By:  
AWD TECHNOLOGIES, INC.  
INDIANAPOLIS, INDIANA**

**AWD PROJECT NUMBER 2259**

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### **NOTICE**

This document is a portion of the overall design package and, therefore, cannot be referenced, in whole or in part, as a stand alone document for any other purpose.

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## **1.0 INTRODUCTION**

### **1.1 Scope of Work**

This Air Monitoring Plan (AMP) has been prepared by AWD Technologies, Inc. (AWD) to define air monitoring procedures to be implemented during the Site Preparation and Material Removal phase of work to be performed at the Environmental Conservation and Chemical Corporation Site (ECC Site) near Zionsville, Indiana. The purpose of this air monitoring will be to assess offsite migration of particulate generated during this phase of remedial activity. Specifically, air monitoring will be performed to assure compliance with applicable or relevant and appropriate requirements (ARARs).

### **1.2 Site Background**

Site operations began in 1977. The site was used for the recovery, reclamation, and brokering of primary solvents, oils, and other wastes. Waste products were received in drums and bulk tankers and then prepared for subsequent reclamation or disposal. Reclamation processes included distillation, evaporation, and fractionation to reclaim solvents and oil.

The ECC Site was placed into receivership in July 1981. Drum shipments to the Site were halted in February 1982. Surface cleanup activities conducted by U.S. EPA and PRP Contractors during 1983 and 1984 included the removal of cooling pond waters, waste drums, tank waste, contaminated soil, and cooling pond sludge.

### 1.3 Anticipated Air Emissions

Site activities have been divided into site preparation and material removal actions, as itemized below.

<u>Activity ID</u>	<u>Activity Description</u>
SP-100	Site Preparation
SP-102	Contractor Mobilization
SP-105	Field Survey and Site Layout
SP-125	Temporary Tank Relocation and Storage
SP-110	Install New Chain Link Fence
SP-120	Pad Grading, Storm Ditches, and Runoff Control
SP-130	Remove Existing Chain Link Fence
SP-160	Decontamination Pad and Wastewater Storage Pad
SP-150	Exclusion Zone Fence
MR-130	Site Debris Removal
SP-140	Regrade and Place Aggregate
SP-145	Temporary Site Facilities and Utilities
MR-100	Material Removal
MR-105	Tank Decontamination and Demolition
MR-110	Drum Characterization and Removal
MR-120	Structure Decontamination, Demolition, and Removal
PC-350	Site Utilities Secured and Winterized
PC-400	Demobilization/Site Cleanup

The primary air emission expected from these activities is fugitive dust. Sources of fugitive dust will include onsite movement of trucks, equipment, and materials. Activity MR-110, the removal of 270 55-gallon drums containing cuttings from prior sampling investigations, would be the only potentially significant source of fugitive volatile and contaminated particulate emissions. Recognizing this, the drum characterization and removal activity will be postponed until the remedial action phase.

As a result of postponing Activity MR-110 until the remedial action phase, there will not be any activities performed during site preparation and material removal that will disturb the existing surface conditions inside the remediation boundary. The only uncontrolled emissions expected will be fugitive dust. Appropriate measures will be taken during site preparation and material removal activities to mitigate fugitive dust emissions.

This AMP is organized as follows:

- Section 2.0 - Describes the regional setting of the Site including climate, topography, receptors, and existing emission sources.
- Section 3.0 - Presents the regulatory requirements under which this AMP will be performed.
- Section 4.0 - The Air Monitoring Program is presented. Topics covered include monitoring locations, monitoring duration and frequency, monitoring methods, and quality assurance/quality control.
- Section 5.0 - Presents the mitigating measures that will be implemented in the event that air monitoring levels exceed allowable limits.
- Section 6.0 - Describes data management and reporting requirements of the ECC Trust's Engineer (Engineer).



## **2.0 REGIONAL SETTING**

This section provides an overview of the climatic and topographic conditions at the Site that are likely to affect the offsite migration of air contaminants. In addition, nearby residences that may be impacted by air emissions from the remedial activities are identified. Finally, existing nearby sources of air emissions that could influence air measurements conducted at the Site are discussed.

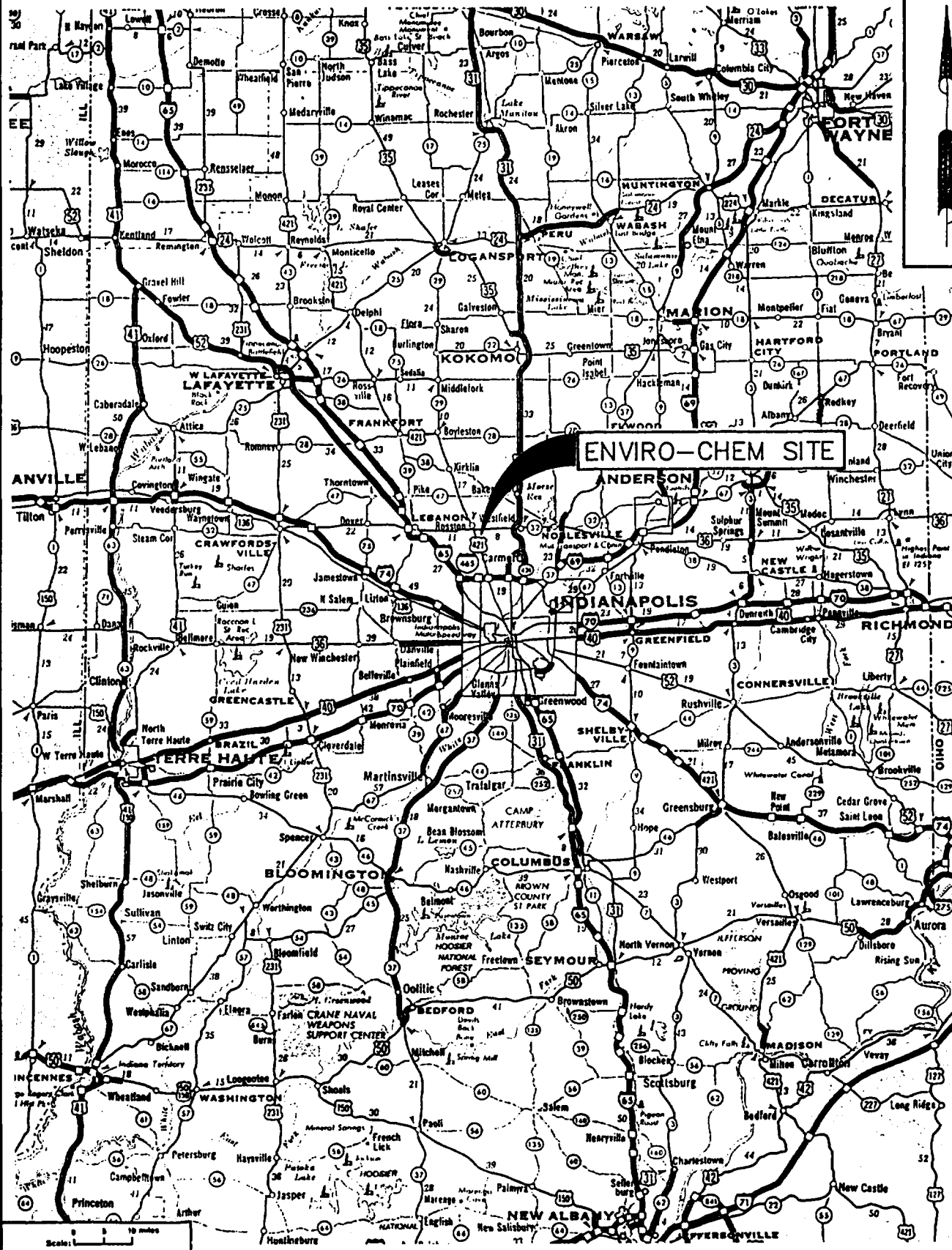
### **2.1 Climate and Topography**

The Site is located approximately 23 miles north of Indianapolis International Airport in central Indiana (see Figure 2-1). The region is characterized by level to slightly rolling terrain. This characteristic is exhibited by the Site area with the exception of a major manmade topographical feature immediately adjacent to the Site.

The Northside Sanitary Landfill (NSL), also a Superfund Site, is located less than 100 feet to the east of the ECC Site property as shown in Figure 2-2. An unnamed ditch separates the two properties. The landfill runs the length of the Site (north to south) and rises to approximately 100 feet above the local terrain (from 880 feet to 980 feet mean sea level (MSL)). The landfill covers an area of about 69 acres (1,500 feet x 2,000 feet).

The Indianapolis region has a temperate climate with very warm summers and no dry season. Summer daytime temperatures normally exceed 80°F. Winter daily minimum temperatures typically drop below freezing from December through March. Precipitation is distributed evenly throughout the year. Normal monthly rainfall is about 2 to 4 inches. Snowfall, which may occur from October through April, amounts to 3 inches or more, two to three times during the winter.

Winds are predominantly from the southwest or west-southwest in the region. This is illustrated by Figure 2-3 which shows the frequency of occurrence of winds during the period 1987-1989. The predominant southwesterly winds may be offset by strong Canadian winter storms that produce northerly flows. Mean monthly wind speeds in the region range from 7 to 11 miles per hour (mph).



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## SITE LOCATION MAP

ENVIRO-CHEM SUPERFUND SITE

ZIONSVILLE, IN

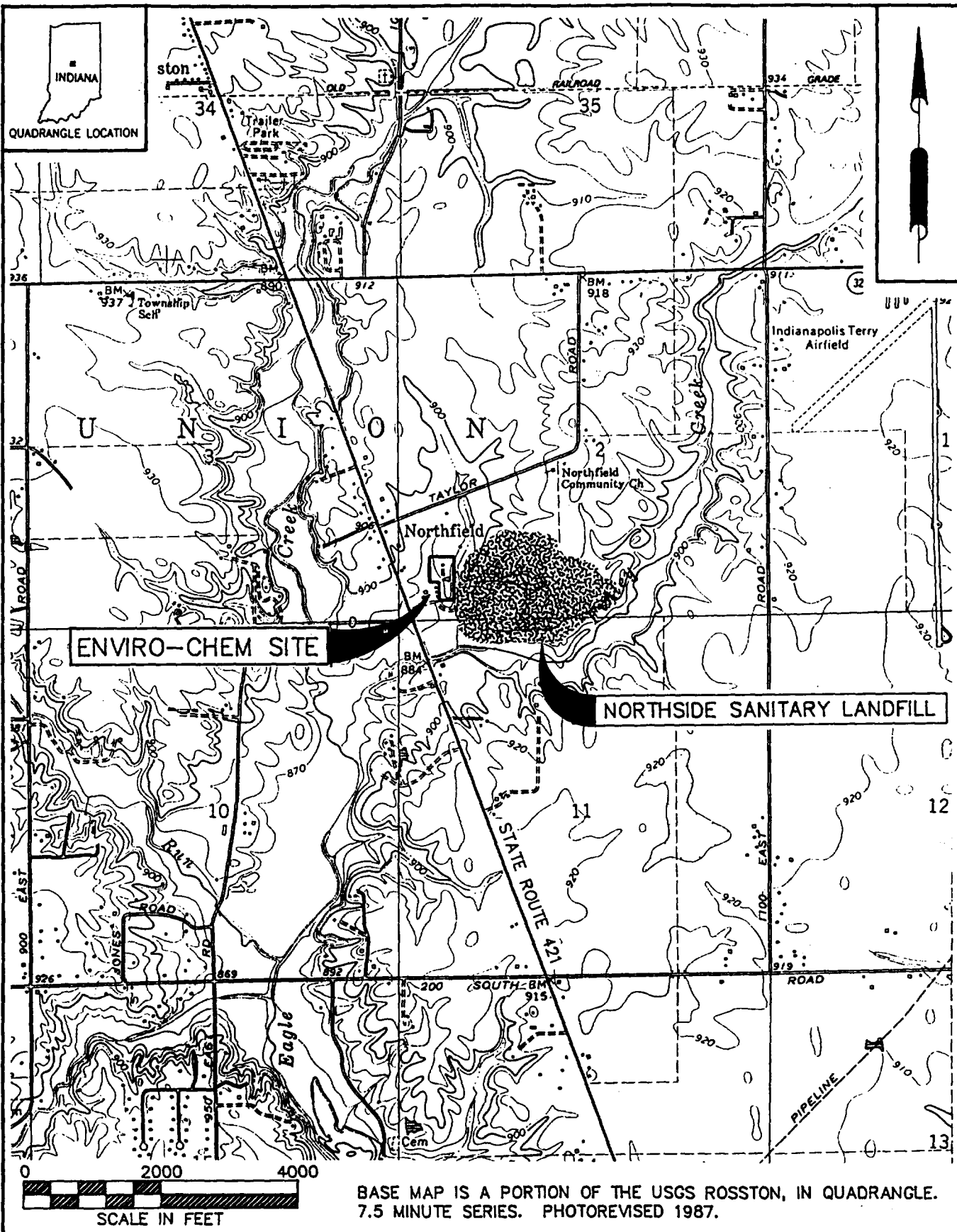
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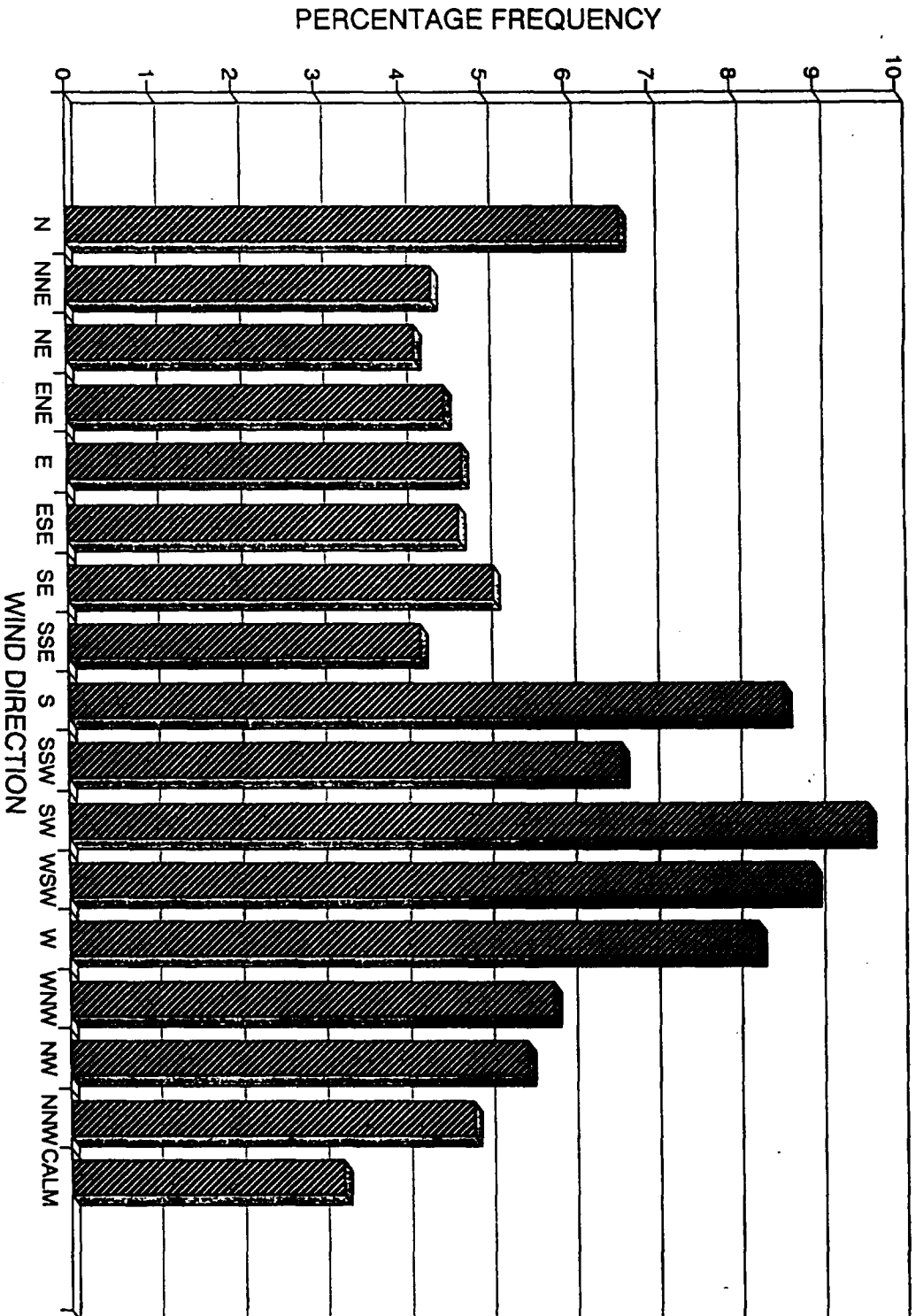
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FIGURE  
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2-1

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AWD TECHNOLOGIES, INC



FREQUENCY OF WIND DIRECTION: 1987-1989

INDIANAPOLIS INTERNATIONAL AIRPORT

ENVIRO-CHEM SUPERFUND SITE

ZIONSVILLE, IN

CLIENT: ENVIRONMENTAL CONSERVATION & CHEMICAL CORP. TRUST JOB NO. 2258-501

SCALE: NONE

FIGURE  
NUMBER

2-3

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## **2.2 Existing Receptors and Sources**

The ECC Site is located in rural Boone County, Indiana. Farmland borders the southern edge of the Site and the eastern edge of the NSL. Residential properties are located to the north and west, within 1/2 mile of the facility. The closest residence is 350 feet west/southwest of the Site. The community of Northfield is located approximately 900 feet northwest of the Site on State Route 421 as shown in Figure 2-2.

Currently, fugitive dust concentrations at the ECC Site may be contributed to by the following sources.

- State Route 421 which is approximately 500 feet to the west of the Site.
- The NSL may be a significant source of fugitive dust because it is not fully vegetated and because operations may be underway there during the Site remediation.
- The owner of the ECC Site is currently operating a temporary transfer station within 100 feet to the west of the Site.
- A recycling operation may be initiated in the near future within 100 feet to the southwest of the Site.
- The Site is bordered on the north and southwest by unimproved roads that may contribute to particulate matter concentrations at the Site.
- Regional farming activities are a significant contribution to ambient particulate concentrations.



### **3.0 REGULATORY REQUIREMENTS**

Air quality standards established by the Federal government and by the State of Indiana are applicable or relevant and appropriate to the control of emissions of fugitive dust from the Site. These standards in addition to other pertinent guidelines are discussed below.

#### **3.1 Federal Standards**

Statutory determinations presented in the Record of Decision (ROD) Amendment for this Site indicate that "some short-term air...releases may occur during the construction of the soil vapor extraction system." Construction of the soil vapor extraction system will not occur during the Site Preparation and Material Removal phase. The ROD also states that onsite activities may create fugitive dust and that any precaution required by state or other applicable laws will be taken during construction to minimize these releases.

The national primary ambient air quality standards for particulate matter have been established by the U.S. EPA at  $150 \mu\text{g}/\text{m}^3$  (24-hour average) and  $50 \mu\text{g}/\text{m}^3$  (annual average). Those standards apply to respirable particles with an aerodynamic diameter less than or equal to 10 microns ( $\mu\text{m}$ ) ( $\text{PM}_{10}$ ). Site preparation and material removal activities in combination with background concentrations should not cause ambient conditions to exceed the 24-hour standard. Real-time monitoring and mitigating measures described in Sections 4.0 and 5.0 will be performed to assure compliance with the 24-hour standard. Given the short duration of the Site Preparation and Material Removal activities (4 months) it is not expected that the annual average concentrations will be significantly affected.

#### **3.2 State Standards**

The Indiana Department of Environmental Management (IDEM) has established ambient air quality and fugitive dust regulations that are pertinent to this remediation project.

### **3.2.1 Ambient Air Quality Standards**

The State of Indiana has established two particulate matter standards: one for total suspended particulate (TSP) and one for  $PM_{10}$  (326 IAC 1-3-4). The 24-hour average maximum permissible air concentrations for these pollutants are  $260 \mu\text{g}/\text{m}^3$  and  $150 \mu\text{g}/\text{m}^3$ , respectively. The annual average standards are  $75 \mu\text{g}/\text{m}^3$  and  $50 \mu\text{g}/\text{m}^3$ , respectively. For this AMP, the  $150 \mu\text{g}/\text{m}^3$  24-hour average  $PM_{10}$  standard will be used as the ARAR. As stated above, it is not expected that the annual average particulate concentrations will be affected by this 4-month activity. Therefore, the annual average state and Federal standards will not be used as ARARs. Real-time monitoring and mitigating measures described in Sections 4.0 and 5.0 will be used to assure that the 24-hour standard is met.

### **3.2.2 Fugitive Dust**

IDEM has established a fugitive dust emissions rule (326 IAC 6-4) that applies to the generation of particulate matter that escapes beyond the property line within which the source is located. In accordance with 326 IAC 6-4-6(3), the site preparation and material removal activities will be exempt from this rule because every reasonable precaution will be taken to minimize fugitive dust emissions from the construction and demolition activities.



## **4.0 AIR MONITORING**

Because site preparation activities are expected to cause minimal disturbance of the ground, it is unlikely that fugitive dust emissions will cause temporary particulate concentrations in excess of the state and Federal 24-hour standard. Nevertheless, if it is determined that unacceptable levels of dust are being generated, the Engineer will restrict some or all activities until dust control measures have been instituted to prevent contaminant migration. This section describes the monitoring to be performed to determine if fugitive dust emissions are unacceptable.

Real-time ambient air monitoring for particulates will be performed as a component of the project Health and Safety Plan. The action levels established for the Health and Safety Plan, shown here in Table 4-1, will be used to assess the significance of perimeter air concentrations.

Air monitoring will be conducted according to the following guidelines.

### **4.1 Air Monitoring Locations**

Air monitoring will be performed with portable handheld instruments while site operations are under way. This will provide the instrument operator with the ability to collect data in the downwind orientation relative to current active areas. Downwind orientations will be determined on the basis of visual observation of wind socks or other visual indicators. It may be necessary to collect data at more than one downwind location on the same day depending on the activities underway and the persistence of the wind direction. Real-time data will be collected at the property boundary within the fenceline. The portable instrument will collect the samples from the breathing zone (about 5 to 6 feet above grade).

Background particulate measurements will be performed at an upwind location on each day prior to collecting downwind data. Background data will be used to assess the significance of real-time measurements in accordance with AALs shown in Table 4-1.

**TABLE 4-1****APPLIED ACTION LEVELS (AALs) FOR PERIMETER MONITORING  
DURING SITE PREPARATION AND MATERIAL REMOVAL**

Constituent	Fenceline Concentration	Response
Particulate	1 to 5 mg/m <sup>3</sup> above background	Notify Engineer, Resident Superintendent, and Site Safety Officer
Particulate	> 5 mg/m <sup>3</sup> above background	Stop work; notify Engineer, Resident Superintendent, Site Safety Officer, and consult with Health and Safety Officer. Institute dust control measures

## **4.2 Duration and Frequency of Monitoring**

Downwind air monitoring will be performed twice daily when site preparation and material removal activities are underway at the site. Samples should be collected at mid-morning and mid-afternoon to ensure that sampling coincides with variations in daily wind regimes. These samples will be of 10-minute duration for comparison to the AALs shown in Table 4-1. A single daily sample will be used to characterize daily upwind conditions. Sampling will not be performed during periods of precipitation unless visible fugitive dust emissions are observed.

## **4.3 Air Monitoring Methods**

A miniature real-time aerosol monitor such as the M.I.E. MINIRAM (Model PDM-3) or its performance equivalent, will be used to measure real-time ambient concentrations of particulate. This instrument provides a measurement range of 0.01 to 100 mg/m<sup>3</sup>.

Air monitoring will be performed in accordance with standard operating procedures provided by the instrument manufacturer. If the MIE Model PDM-3 is selected by the Contractor, the MIE operating procedures included in Appendix A will be followed. Adherence to these procedures will ensure the comparability and reliability of the results obtained from the instrument. The unit will be calibrated on a daily basis as specified by the manufacturer.

The recommended procedure for determining compliance with the AALs is as follows:

1. Identify active area of site preparation or material removal.
2. Identify predominant wind direction with wind socks or other visual indicators.
3. Move instrument to an upwind orientation and collect a 10-minute average samples (with instrument intake in the breathing zone). The instrument may be mounted on a tripod to facilitate sample collection.
4. Record "upwind" concentration.
5. Move to a downwind fenceline location and collect 10-minute average sample.

6. Subtract upwind concentration from downwind concentration.
7. Compare result to Table 4-1 AALs and implement responses as needed.

The AALs shown in Table 4-1 will be protective of the state and Federal ambient air quality standards. This is demonstrated by the following hypothetical scenario that assumes the AAL of 500  $\mu\text{g}/\text{m}^3$  above background is exceeded at the downwind station. After the 10-minute reading, the technician takes 10 minutes to notify the Engineer, Resident Superintendent, and Site Safety Officer. Finally, operations are halted and dust suppression is initiated after a total of 30 minutes have elapsed. As a result, the measured air concentrations assuming a background concentration of 100  $\mu\text{g}/\text{m}^3$ , will be as follows:

<b>HYPOTHETICAL MONITORING AND RESPONSE SCENARIO</b>		
Time (Min)	Concentration ( $\mu\text{g}/\text{m}^3$ )	Action
1 to 10	600	Perimeter downwind monitoring
10 to 20	600	Technician notifies Engineer
20 to 30	600	Operations are halted and dust suppression initiated
31 to end of 24-hour period	Background (assume 100 $\mu\text{g}/\text{m}^3$ )	Dust suppression maintained for duration of this activity or until wind conditions subside

A 24-hour (1,440-minute) average concentration (assuming background of 100  $\mu\text{g}/\text{m}^3$ ) would be calculated as follows:

$$\frac{(30 \text{ min} \times 600 \mu\text{g}/\text{m}^3) + (1,410 \text{ min} \times 100 \mu\text{g}/\text{m}^3)}{1,440 \text{ min}/24\text{-hours}} = 110.4 \mu\text{g}/\text{m}^3\text{-day}$$

This calculation demonstrates that even if background concentrations are about  $100 \mu\text{g}/\text{m}^3$ , a 30-minute event of  $600 \mu\text{g}/\text{m}^3$  ( $500 \mu\text{g}/\text{m}^3$  above background) would cause only a small increase over the existing 24-hour ambient condition, and it would still be within the state and Federal standards. For the example provided, even if the time from the first detection of the AAL excess to control of emissions was 2 hours, the associated 24-hour average would not exceed the state or Federal standard.

#### **4.4 Quality Assurance/Quality Control**

The Air Monitoring Program will incorporate a two-component approach for routine QA/QC checks as follows:

- Use of collocated samples for precision checks
- Equipment calibrations

One set of real-time measurements will be simultaneously collocated at a downwind station for 10 percent of the sampling activities (e.g., collocated sampling performed every 10th sampling day). Comparison of the results for collocated samples will be used to evaluate the reliability of data obtained in the field.

Calibration of sampling instruments will be performed in accordance with the manufacturer's recommendation on a daily basis.

#### **4.5 Organization and Responsibilities**

This real-time air monitoring will be carried out as a component of the Health and Safety Plan. Therefore, the organization and responsibilities identified in the Health and Safety Plan will be adhered to for execution of this AMP.



## **5.0 MITIGATING MEASURES**

Engineering controls for fugitive dust are described in the Environmental Control and Maintenance Plans (ECMP) for this project. The following measures will be taken at all times to minimize the likelihood that fugitive dust will be emitted from the site:

- The Contractor shall take measures necessary to minimize tracking of mud and dirt onto adjacent public roadways. These measures shall include a gravel construction entrance. Adjacent public roadways shall be cleaned as often as necessary to maintain a dust and mud free surface.
- The Contractor shall take measures necessary to minimize unnecessary dust. Earth surfaces subject to dusting shall be kept moist with water. Dusty materials in piles or in transit shall be covered to prevent blowing.

If perimeter monitoring indicates that the  $500 \mu\text{g}/\text{m}^3$  above background AAL has been exceeded, then the following dust control measures will be considered:

- Cease activities until more favorable conditions exist
- Apply water over the area(s) of concern
- Apply calcium chloride over the area(s) of concern

The Contractor will proceed with implementation of dust control measures only after approval by the Engineer.



## **6.0 DATA MANAGEMENT AND REPORTING**

### **6.1 Air Monitoring Documentation**

Complete and detailed documentation of real-time air monitoring activities will be a key factor in the air monitoring program. Required documentation will include the following:

- Field log
- Sample information sheets
- Calibration data records

A field log will be used by the field technician to maintain a record of daily sampling activities. Information to be recorded will include: sample dates, sampling conditions, site preparation activities under way, and sampling locations. Notes will also address equipment condition, sampling problems, or equipment failures. Copies of field logs will be included in the Air Monitoring Program Report described in Section 6.2.

Sample information sheets will be completed by the field technician for each sample. The information included will be similar to that required for field log entries. However, the sample information sheets will be sample-specific and will be considered the primary sample collection documentation. Conversely, the field log is a back-up documentation source and presents information on a chronological basis. Copies of each sample information sheet will be submitted to the Engineer on a weekly basis unless an AAL is exceeded. In the latter case, the information sheet will be delivered to the Engineer at the earliest opportunity. All sample information sheets will be included in the respective Monitoring Program reports.

Calibration data records will document required periodic calibrations and any other maintenance activities for individual samplers. Calibration data records will be submitted to the Engineer following each calibration.

## **6.2 Monitoring Program Reports**

An Air Monitoring Program Report will be submitted within 30 days of the conclusion of the Site Preparation and Material Removal activities. The report will provide a tabular summary of monitoring results and all associated QA/QC documentation. All occurrences of air concentrations in excess of the established AALs, will be identified. In addition, a discussion of mitigating measures that were applied in response to any AAL exceedances will be provided.

A draft version of each Air Monitoring Program Report will be submitted to the Engineer for review. A final report will be provided within 7 days of receipt of the Engineer's comments.





**APPENDIX A**

**MINIRAM PERSONAL MONITOR MODEL  
PDM-3 OPERATIONS MANUAL**

**MINIRAM PERSONAL MONITOR  
MODEL PDM-3  
OPERATIONS MANUAL**

**March 1990**

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## WARRANTY

### ONE YEAR LIMITED WARRANTY

MIE warrants to the original Purchaser that the apparatus to be delivered hereunder will be of the kind designated or specified and free of defects in workmanship or material. MIE makes no other express warranty, and disclaims any implied warranty of merchantability or fitness for purpose.

If the apparatus fails to conform to the above warranty, and notice is received by MIE from Purchaser within one year from the date of shipment, MIE will, at its option, either repair the defective part or parts or make available a repaired or replacement part. This warranty extends to all parts and labor involved in the required repair to the extent that said repair was not caused by negligence in operation of the apparatus by the Purchaser. MIE will perform the repair at its plant with all shipping and insurance costs paid by the Purchaser or, upon, mutual consent of the parties, at a site designated by the Purchaser except, in the latter circumstances, the Purchaser will be responsible to reimburse MIE for all costs associated with travel, per diem, and travel time of those MIE individual(s) deemed appropriate to effectuate the repair.

Repair or replacement of the apparatus in the manner and for the time period specified above, is the Purchaser's exclusive remedy and will satisfy all liabilities of MIE to Purchaser arising out of the supply or use of the apparatus, whether based on contract, warranty, negligence or otherwise. In no event will MIE be liable for any incidental or consequential loss or damage from any failure of the apparatus to conform to the contract of sale.

## 1.0 DESCRIPTION

### 1.1 Sensing Method

The MINIRAM (Miniature Real-time Aerosol Monitor) Model PDM-3 is an ultra-compact personal-size airborne particulate monitor whose operating principle is based on the detection of scattered electromagnetic radiation in the near infrared. The MINIRAM uses a pulsed GaAlAs light emitting source, which generates a narrow-band emission (half-power width of 80 nm) centered at 880 nm. This source is operated at an average output power of about 2 mW. The radiation scattered by airborne particles is sensed over an angular range of approximately 45° to 95° from the forward direction by means of a silicon-photovoltaic hybrid detector with internal low-noise preamplifier. An optical interference-type filter is incorporated to screen out any light whose wavelength differs from that of the pulsed source.

The MINIRAM is a light scattering aerosol monitor of the nephelometric type, i.e., the instrument continuously senses the combined scattering from the population of particles present within its sensing volume (approximately 1 cm<sup>3</sup>) whose dimensions are large compared with the average separation between the individual airborne particles.

### 1.2 Open Sensing Chamber Sampling Method

Air surrounding the MINIRAM passes freely through the open aerosol sensing chamber as a result of air transport caused by convection, circulation, ventilation, and personnel movement. The MINIRAM requires no pump for its operation, and the scattering sensing parameters have been designed for preferential response to the particle size range of 0.1 to 10 micrometers, ensuring high correlation with standard gravimetric measurements of both the respirable and inhalable size fractions. Optional flow accessories are available for applications requiring specific inertial particle precollection, extractive sampling, concurrent filter collection, etc.

It should be noted that one of the advantages of direct light scattering aerosol sensing is that the rate at which air passes through the sensor does not influence the indicated concentration because the detection is performed directly on every parcel of air traversing the fixed sensing volume. Therefore, flow velocity through a real-time sensor such as the MINIRAM influences only the response time. So, it should not surprise the first-time user when, upon pressing the MEAS key of the MINIRAM, no pump noise is heard, and this silence will be accompanied by a readout message of "GO" on the liquid-crystal display indicating that the MINIRAM has, indeed, been activated.

### 1.3 MINIRAM Electronics

The MIE MINIRAM is a very advanced aerosol monitor which incorporates a custom-designed single-chip CMOS microprocessor whose functions are to: process the signal from the light scattering detection circuit, control the measurement sequence program, compute concentration averages, keep record of elapsed time, perform automatic zero correction, control auto-ranging, drive the liquid-crystal-display, store average concentration values as well as timing and identification information, sense battery and overload conditions, sequence playback of stored information, and provide alarm signals.

The MINIRAM derives its power from a set of internal rechargeable Ni-Cd batteries which can provide continuous monitoring operation for over 8 1/2 hours, or retain stored information for up to approximately 6 months. The battery set is packaged as a separable module which allows easy field replacement when recharging is not feasible. The MINIRAM can be run without time limit from an A.C. line using the charger provided with the instrument.

During the normal monitoring operation, the liquid-crystal-display indicates the aerosol concentration in the units of milligrams per cubic meter, and the displayed reading is updated every 10 seconds. When operating in the measurement or monitoring mode, other functions can be displayed momentarily, i.e., as long as a corresponding touch switch is pressed. All external controls are performed by pressing one or more of 8 sealed touch switches on the MINIRAM panel. Stored information playback can be accomplished either by means of the MINIRAM's own display or through the digital output jack. The MINIRAM has two output connectors. One provides a continuous, real-time analog signal output proportional to the aerosol concentration. This signal can be used for continuous recording (e.g., on a strip chart recorder), telemetry, or control purposes, etc. The other connector provides, during the measurement mode, either an ASCII digital output of the 10 second averages, or a switched output for alarm purposes (depending on the user-selected function).

### 1.4 Modes of Use and Application

The MINIRAM measures the concentration of any airborne particles, both solid and liquid, and the display indicates this level in the units of milligrams per cubic meter, based on its factory calibration, against a filter-gravimetric reference, using a standard test dust (Arizona road dust). The MINIRAM can be used to measure the concentration of all forms of aerosol: dusts, fumes, smokes, fogs, etc.

Its small size and weight, and concentration averaging features permit its use as a personal exposure monitor, attached to a belt, shoulder strap, hard hat, etc. Alternatively, it can be used as an area monitor for both indoor and ambient air situations. Test chamber monitoring, visibility measurements, cloud detection (e.g., radio/drop sonde), aerosol dispersion studies, etc. are additional applications of the MINIRAM.

## 2.0 WHEN YOU RECEIVE THE MINIRAM ...

Follow these steps when first receiving your MINIRAM:

- 2.1. Remove the instrument from shipping case.
- 2.2. Observe display. It should be blank indicating that the MINIRAM is in the minimum power mode.
- 2.3. Plug charger into A.C. line (standard charger is for 120V, 60 Hz; optional version available for 220V, 50 Hz).
- 2.4. Connect charger plug into corresponding MINIRAM receptacle.
- 2.5. Leave charger connected to MINIRAM for a minimum of 8 hours before using instrument without the charger.
- 2.6. You can operate the MINIRAM immediately after the charger has been connected. Follow operating instructions described in the next section of this manual.

## 3.0 OPERATING INSTRUCTIONS

Refer to Figure 1 for the location of control switches, display, and connector jacks. Refer to Figure 2 for the display timing sequences.

### 3.1 Initial Condition

Assuming that the batteries of the MINIRAM have been recharged (see section 2.0), the display may indicate one of the following conditions:

- **Blank display:** Means the MINIRAM had not been in the measurement mode for 48 hours or more, and is in the minimum power off mode.
- **"OFF" display:** MINIRAM has been in the off mode for less than 48 hours.
- **Concentration display that changes or "blinks" once every 10 seconds:** the MINIRAM is in the measurement mode.

### 3.2 To start Measurement Cycle

- If the MINIRAM shows a blanked display (see above), press OFF and wait until the display reads "OFF" (approximately 5 seconds after pressing OFF), before pressing MEAS to initiate measurement cycle.
- If the MINIRAM shows "OFF" (see above), press MEAS directly to initiate measurement cycle (there is no need to press OFF first, in this case).

The functions performed by pressing each MINIRAM touch switch are as follows:

### 3.3 MEAS

To start the monitoring operation of the MINIRAM, Press MEAS (see automatic timing sequence of Figure 2). The first readout displayed is either "GO" (or "CGO" if TIME is also pressed, section 3.4), followed by the last concentration reading or ".00". Approximately 36 seconds after pressing MEAS the first new 10-second averaged concentration reading is displayed. All subsequent readings are concentration values in milligrams per cubic meter, updated every 10 seconds. Figure 3 shows a typical digital printout of a sequence of 10-second measurements (second data block).

The MINIRAM will now run in the measurement mode for 500 minutes (8 hours and 20 minutes), after which it will stop, displaying the OFF reading, retaining in storage the concentration average and elapsed time information. Once the MEAS mode has been entered this sequence can only be interrupted by pressing OFF; pressing ZERO, TWA, SA, TIME or ID# only affects the display during the time these keys are pressed, without affecting the measurement cycle. Pressing PBK during this cycle has no effect.

The instrument normally operates in the .00 to 9.99 mg/m<sup>3</sup> range. Whenever a 10-second concentration exceeds 9.99 mg/m<sup>3</sup> the MINIRAM display automatically switches to the .0 to 99.9 mg/m<sup>3</sup> range and remains in that range as long as the measured 10-second concentration exceeds 9.99 mg/m<sup>3</sup>, otherwise the MINIRAM reverts to its lower range display.

### 3.4 MEAS and TIME

If both MEAS and TIME are pressed at the same time (press TIME first and while depressing it actuate MEAS) the MINIRAM will display "CGO" (for Continuous "GO"), and will then operate as above (i.e., pressing MEAS only), except that after the first 8.3 hour run it will restart automatically and continue to measure for an indefinite number of 8.3 hour runs, (with the battery charger) until the OFF key is pressed, or until the batteries are exhausted at which time the MINIRAM shuts off automatically, displaying the "OFF" reading. Concentration averages and timing information for the last seven 8.3 hour runs will remain in storage at any given time.

### 3.5 OFF

When this key is pressed the MINIRAM will discontinue whatever mode is underway displaying "GCA"\* followed by the display segments check ("8.8.8=") and finally "OFF" (see timing diagram of Figure 2). The MINIRAM will then remain in this reduced power condition (displaying "OFF") for a minimum of 10 minutes or a maximum of 48 hours or until the MEAS key is pressed to resume the measurement cycle.

If OFF is pressed during a measurement run the display will read "OFF" for 48 hours (unless another key is pressed during that period), after which the display will be blanked. If OFF is pressed while the display is blank, the MINIRAM will display the "OFF" reading for only 10 minutes, after which the display will be blanked again unless another key is pressed during that period.

Every time the OFF key is pressed, during a measurement cycle, the MINIRAM will store the concentration average and elapsed monitoring time up to the time of that OFF command. The duration of the off period (up to 48 hours), i.e., between two consecutive measurement cycles, is also stored for each of up to 7 cycles.

If the MINIRAM is not reactivated (i.e., pressing MEAS) within 48 hours of the OFF Command, it automatically switches to a minimum power level, with blanked display; however, all data remains stored in memory for up to approximately 6 months without battery recharging (indefinitely, with charger).

OFF must be keyed before any other operating mode can be entered: setting ID#, zero referencing, playing back stored data, or changing the program code. Display functions, however, can be activated during the measurement mode.

### 3.6 TIME

During the measurement mode, if TIME is pressed the display will show the elapsed time, in minutes, to three significant figures, from the start of the last measurement run. The MINIRAM will automatically return to concentration display after the TIME key is released.

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\* "GCA" is displayed and printed out by the MINIRAM although the instrument is manufactured exclusively by MIE, Inc.

### 3.7 TWA

This key stands for Time-Weighted-Average. During the measurement mode, if TWA is pressed the display will indicate the average concentration in milligrams/m<sup>3</sup> up to that instant, from the start of the last run. This average is computed by the MINIRAM applying the equation:

$$TWA = \frac{1}{t} \int_0^t C dt$$

where t is the elapsed run time and C is the instantaneous concentration at time t. The value of TWA is updated every 10 seconds. After releasing the TWA key the MINIRAM display returns to the 10-second concentration display.

### 3.8 SA

This key stands for Shift-Average. During the measurement mode, pressing SA will provide a display of the aerosol concentration, up to that moment, averaged over an 8-hour shift period. This average is computed by the MINIRAM applying the equation:

$$SA = \frac{1}{480 \text{ min.}} \int_0^t C dt$$

The shift-average value corresponds to the exposure from the start of the measurement cycle. Thus, for example, if the MINIRAM has been measuring for 3 hours, and the time-weighted average over that period has been 6 mg/m<sup>3</sup> (TWA reading), the shift average value at that time, (SA reading) would be 2.25 mg/m<sup>3</sup>, which is equivalent to an 8-hour exposure at an average concentration of 2.25 mg/m<sup>3</sup>.

The value of SA is updated every 10 seconds. When releasing the SA key the MINIRAM display returns to the 10-second concentration display.

### 3.9 PBK

With the MINIRAM in the off mode (i.e., not in the measurement mode), the stored information can be played back by pressing PBK. If the PBK key is initially pressed the display will indicate "P" for one second. If PBK continues to be pressed for more than 1 second, then the stored data is automatically played back through the MINIRAM display: First, the identification number is displayed with the ID indicator bar on; next the shift or run number (7 through 1, i.e., starting with the last run) is shown (with the OVR indicator bar on as identification); followed by the sampling (i.e., measurement) time in minutes, for that run; followed by the off-time between the last and next run (in tens of

minutes); finally, the average in  $\text{mg}/\text{m}^3$ .<sup>\*</sup> This sequence is repeated seven times. An average reading of 9.99 indicates that a significant overload condition occurred during that run. The total time required for the complete automatic playback on the MINIRAM display is approximately 70 seconds.

If PBK is pressed for less than one second "PA" will be displayed, and the stored data will be fed out through the digital output jack of the MINIRAM for printout, magnetic storage, telemetry, etc. A printout consists of 8 lines of data. Figure 3 shows a typical stored data printout (see data block labeled "Playback of Stored Data"). The first 7 lines show the data for the last 7 measurement periods, and the last line shows the identification number (I), the programmable selection code (F), and the zero value for that data block (Z). In addition a check sum is printed out on a 9th line for modem/computer data transfer purposes. The first 7 data lines are subdivided into 4 columns. The first column identifies the measurement period (starting with the last or 7th); the next column lists the corresponding duration of each measurement period, in minutes; the third column lists the off time between consecutive measurement periods, in minutes divided by 10; and the last column lists the average concentration values for each period in  $\text{mg}/\text{m}^3$ .<sup>\*</sup>

Either time-weighted, or shift average values can be printed, depending on the selected programmable code (see section 4.2). The example shown on Figure 3 (F=0012) indicates that the TWA values are listed. Although the printout heading will indicate "PDM-2 LISTING" (as shown in Figure 3), this format applies equally to the MINIRAM model PDM-3.

The speed of the digital transfer to a printer or other digital device can be user selected through the programmable selection code (see section 4.2). For a 300 baud rate the transfer time for the stored data block is approximately 45 seconds. See sections 10.0 and 11.0 for instructions on how to connect the MINIRAM to a printer or other digital recording/processing device.

### 3.10 ZERO

The interior walls of the MINIRAM sampling chamber reflect a small amount of the light from the infrared source into the detector. This background level is referred to as the "zero value", and is automatically subtracted from all aerosol concentration readings during the measurement mode. The result is that the displayed readings depend only on the actual dust concentration present within the sensing chamber.

The zero value varies from instrument to instrument as well as with different sensing chambers. It will increase somewhat as the chamber inner walls and windows become contaminated with dust. A zero update should be performed after cleaning the sensing chamber (see section 12.0).

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<sup>\*</sup> Either the TWA or the SA values, depending on selected user-programmable code (see Section 4.2).

Pressing ZERO during a measurement period provides momentary display of the stored zero concentration value used by the MINIRAM to correct all digital concentration readings (the analog output signal is not zero-corrected). To update the ZERO value the MINIRAM must be in its off condition (press OFF in case of doubt). Then, press ZERO and wait until the display again indicates "OFF".

The average of 4 consecutive 10-second zero level measurements will then be stored by the MINIRAM as the new ZERO reference value. (See timing diagram in Figure 2 and digital printout obtained during a typical zero check on Figure 3). When operating the MINIRAM in high particle concentration environments ( $>5 \text{ mg/m}^3$ ) the zero value update should be performed approximately every 8 hours. At aerosol concentrations below approximately  $1 \text{ mg/m}^3$  this update may only be required once a week, or even less frequently. The zero update should be performed either within a clean-air environment (ideally, a clean room or clean-bench) or using one of the accessories provided by MIE for that purpose: either the Z-Bag (standard accessory, see Section 16.3), or the Zero Check Module PDM-1FZ (optional accessory, see Section 17.2). The latter should be used for zeroing only when subsequent measurements are at concentrations greater than approximately  $0.5 \text{ mg/m}^3$ , or if the PDM-1FZ is left on the MINIRAM for active air sampling (see Section 17.2). Air conditioned offices (without smokers) usually have concentrations below approximately  $0.05 \text{ mg/m}^3$  and can thus be used for zeroing purposes, if a Z-Bag is not available (see Section 16.3 for instructions on the use of the Z-Bag). When measurements are performed under essentially clean air conditions, e.g., in the same environment where the zero check was performed, the MINIRAM readings will indicate  $0.00 \text{ mg/m}^3$  with small random fluctuations around that value. Positive values (e.g.,  $0.02$ ) will thus be indicated on the LCD display. Negative values (e.g.,  $-0.02$ ) are suppressed and are also indicated as  $0.00$ . The digital output, however, does include such negative values and these will be printed out by a digital printer (see sections 10.0 and 11.0).

### 3.11 ID#

Pressing ID# during a measurement period provides momentary display of the identification number stored within the MINIRAM memory.

The ID# key, in combination with other keys, is used for several additional programming functions described in the next section (4.0).

## 4.0 PROGRAMMABLE FUNCTIONS

### 4.1 ID# Selection

In order to change the instrument identification number the MINIRAM must first be in the off mode (i.e., press OFF). Then press the ID# key, and the presently stored number (between 1 and 999) will be displayed, as well as the ID indicator bar. To increment the identification number press the ▲ key (same key as TWA), and to decrement the number press the ▼ key (same key as SA). Any number between 1 and 999 can thus be selected and will remain in storage until

the batteries are disconnected, or if the MINIRAM is not recharged over a 6-month period.

Pressing the OFF key after the above identification number selection will remove the MINIRAM from the ID# selection routine and lock-in that number until a new number is selected. A complete ID# lock-out (i.e., a routine to preclude panel-control change of that number) can be accomplished by a separate programmable code selection (see section 4.2).

## 4.2 Programmable Selection Code

The programmable code allows the user to panel-select several alternate functions and operating modes.

The program codes to select specific alternate operating modes are:

- 1 selects the alarm instead of ASCII digital output
- 2 selects the ID# lock-out
- 4 selects the TWA instead of the SA to be stored for playback
- 8 selects a 1-second pause after each printer carriage return (for slow printers)
- 32 selects 110 baud digital output rate instead of 300 baud
- 64 selects 600 baud digital output rate instead of 300 baud

These numbers are entered as a sum, e.g., to implement ID# lock out, TWA storage, and 1-second carriage return delay, the code number would be 14 (2+4+8).

To enter the desired code (e.g., 14) follow these steps:

- Press OFF key and wait until "OFF" is displayed.
- Press ID# key and set program code to desired number (e.g., 14) by means of the ▲ and ▼ keys.
- Press TIME key (this will show previously entered code).
- Press ID# key again to lock in the new program code which will then be displayed.
- The preceding steps will cause the ID# to become equal to the programmable selection code. To restore the desired ID# (without affecting the selected code number which is now locked in), use the ▲ and ▼ keys again to select the ID# for the instrument as described in section 4.1.

- Press OFF to exit the ID# selection routine.
- To look at the programmed code number, at any time, start from the off condition; press ID#, then press TIME ("F" will then be displayed momentarily), after which the code number will be displayed. Press OFF to exit the code number routine.

If no specific alternate code is entered the MINIRAM will operate in its standard mode (equivalent to code 12) consisting of the following:

- ASCII digital output
- Panel-selectable ID number (preset to 999)
- Time-Weighted Average (TWA) values in memory storage
- 7-bit ASCII resolution
- 300 baud digital output
- Printer carriage return followed by a 1 second delay

#### 4.3 ID# Lock-out

If the ID# lock-out code has been selected (i.e., a 2 as part of the sum, as described in section 4.2) then both the ID# and the programmable code can only be displayed (and printed out), but neither of the two can then be changed by means of the panel keys. In this case, in order to change the ID# if the lock-out code has been selected, or too alter the programmable code, the battery must be unplugged momentarily. Disconnecting the battery, however, causes the MINIRAM to lose all stored data, and cancels all alternate program codes which may then be restored following the procedure described in section 4.2.

#### 4.4 Alarm Level Adjustment

If the selected program code includes a 1, the MINIRAM will not provide an ASCII digital output but instead a switched output (at the digital output connector) which will close every time the measured 10-second concentration value exceeds a presettable threshold concentration level. If a 1 has been included in the code, then the ID# divided by 10 becomes the alarm level in milligrams/m<sup>3</sup>. This level can be adjusted following the ID# selection procedure of section 4.1, that is using the ▲ and ▼ keys to increment or decrement the number. For example, if an alarm level of 12.5 mg/m<sup>3</sup> is desired (and starting from the off mode), press ID#, adjust displayed number to 125 with the ▲ and ▼ keys, and press OFF. This number (e.g., 125) then becomes the ID# as well. It is not possible to enter a separate alarm level and ID# number.

## 5.0 OVERLOAD, ERROR CODES AND TROUBLESHOOTING

### 5.1 Bar Displays

There are three bar indicators on the MINIRAM display, identified as OVR, ID, and BAT. If the OVR bar is displayed at any time during operation in the measurement mode the MINIRAM detection circuit has been overloaded. A momentary overload can be caused by the insertion of an object into the sensing chamber, sudden exposure to sunlight, etc. If the cause of overload is eliminated, the OVR bar will disappear during the next 10-second display period, unless the overload persists for more than a total of 1 1/2 minutes over an 8 1/3 hour measurement cycle.

The ID bar display is activated only for display identification purposes and not for error conditions.

The BAT bar is displayed when the battery voltage becomes insufficient, indicating that the charger should be plugged into the MINIRAM.

### 5.2 Error Codes

The MINIRAM will display and output (at the digital output jack) error code numbers along with the corresponding overload indicator bars on the LCD readout. These codes will appear only if the problem persists for more than about 30 seconds.

The error code numbers are as follows:

- .0.1: low battery condition
- .0.2: RAM (digital processing)
- .0.3: A/D (signal) overload

If an overload condition persists for more than approximately 1 1/2 minutes the selected concentration average value (SA or TWA) automatically registers 9.99 and that number will be indicated (or digitally transmitted) upon data playback, signifying an invalid measurement cycle. The OVR bar will then remain on for the rest of that run.

### 5.3 Basic Troubleshooting

1. No response when OFF key is pressed, display remains blank
  - a) Batteries exhausted, recharge battery pack. If after charging, unit still does not function, check the following:
  - b) Measure output of battery charger. A volt meter should read about 24.5 V a.c.

- c) If charger is ok, remove battery pack and slightly separate 2 gray connectors. Attach voltmeter + lead to red wire and - lead to black wire. Voltmeter should read about 8.5 Vd.c. while plugged into the charger.
- d) If battery pack is ok check the fuse on the circuit board. Fuse is located 3/8 inch behind analog output jack and is designated F1 on the circuit board. Leaving the - lead of the voltmeter connected to the battery pack use + lead to check voltage on both sides of fuse. Voltage should be the same as in C above. If not, fuse must be replaced. This is preferably done at the factory.

## 2. Unit constantly displays .03-

This indicates electronic component failure. Unit should be sent back to MIE for repair and recalibration.

## 3. Improper Display segments appear

Usually an indication that the circuit board and/or display board has been contaminated. This may be corrected by removing the battery pack and cleaning affected areas with a small brush. Do Not Use any cleaning fluids or solvents on circuit boards. If brushing does not correct problem unit should be sent to MIE for repair.

## 4. Pressing TWA, ID, TIME keys, etc. during MEAS mode causes unit to shut off

- a) Keypad failure: Unit should be sent for repair
- b) Display board contamination: clean board as in 3 above

## 6.0 SENSING CHAMBER REMOVAL AND INSERTION

During normal operation of the MINIRAM the removable sensing chamber (see Figure 1) must be properly inserted, i.e., pushed all the way into the MINIRAM towards the display/control panel end of the instrument. When this chamber is properly positioned the surface on the opposite end from the display/control panel will be approximately flush with the body of the MINIRAM.

To remove the sensing chamber, gently push it away from the display/control panel end, using both thumbs, sliding it out of its channel. This will expose the shouldered metal button with its small spring-loaded plunger, and the two lenses (illumination and detection lenses). Touching of these lenses should be avoided to prevent their soiling. Lens tissue should be used if cleaning of these lenses becomes necessary.

The removable sensing chamber has two small glass windows which should be kept clean (see section 12.0 on routine maintenance).

The sensing chamber is partially closed at one of its open ends. This end is inserted first when sliding the chamber back into the MINIRAM channel. A

small shouldered slot is provided on the underside of the removable sensing chamber for the metal button that serves to retain the chamber.

To reinsert the sensing chamber simply slide it back into position making sure that the chamber is moved parallel to the MINIRAM body. Ensure complete insertion, as mentioned above.

## 7.0 BATTERY PACK

### 7.1 Battery Pack Replacement

The battery pack of the MINIRAM (MIE Part No. PDM-1-101-1) constitutes an intrinsically safe sealed module that can be removed and replaced. To do so, remove the four central screws from the back of the MINIRAM case (not the two corner screws), and gently lift the battery pack up and out, and gently pull apart the battery connector, freeing the battery pack. Reverse order of steps when installing another pack.

<b>CAUTION: ALL STORED DATA WILL BE LOST WHEN DISCONNECTING BATTERY</b>
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After reconnecting battery pack, the ID resets to 999 and an automatic zero reference check is performed by the MINIRAM.

Separate battery packs can be used whenever a.c. line power is unavailable to recharge the pack within the MINIRAM. These spare parts can be recharged independently from the MINIRAM by plugging the charger into the charge receptacle which is an integral part of the battery pack (see figure 1).

### 7.2 Battery Charging

When the MINIRAM battery pack is discharged (see Section 5.0) the MINIRAM batteries should be recharged for a minimum of 14 hours, using only the charger provided with the MINIRAM (Model PDM-1-157-1). The charger can be left connected for an indefinite time to the MINIRAM without danger of overcharging. It is advisable to occasionally discharge the batteries completely (see Section 3.4) and then recharge them as described above, in order to maintain their full capacity.

## 8.0 CALIBRATION ADJUSTMENT

Although every MINIRAM has been factory-calibrated using a representative dust (see section 1.4), the user may wish to change the calibration constant of the instrument for a specific type of aerosol. Such a calibration should be performed by obtaining a concurrent filter collection (e.g., by means of a personal filter sampler), sampling from the same environment within which the MINIRAM is placed. The average concentration obtained by the MINIRAM (i.e. TWA reading) at the end of the test should be compared with the filter-gravimetric-determined concentration. The ratio of the two concentration values can then be used to correct the MINIRAM calibration. The comparison run should be replicated several times (to minimize errors) to obtain an average ratio.

To change the MINIRAM calibration proceed as follows:

- 8.1 Place MINIRAM in a clean environment (e.g. air conditioned office).
- 8.2 Remove battery pack (follow procedure of section 7.0).
- 8.3 Disconnect battery connector (remember that all stored data will thus be lost/erased from MINIRAM memory).
- 8.4 While leaving battery pack lying next to MINIRAM, re-connect the two units (i.e. plug in connector).
- 8.5 Immediately observe MINIRAM display. It will be performing a slow segment-by-segment display checkout. As soon as it displays ".00", press OFF, thus interrupting the initial automatic zero check (see section 7.0). Wait until the display indicates "OFF" and then press MEAS and wait approximately 36 seconds.
- 8.6 Observe 10-second readings (typically in the range of 1 to 3 mg/m<sup>3</sup>) and record manually a few consecutive readings. Calculate the average of these values.
- 8.7 Identify small potentiometer screw (visible through an opening in the foil shield of the open MINIRAM) opposite the digital output jack. Adjust this potentiometer, using a fine screw driver, until the average MINIRAM reading is increased or decreased (with respect to the average obtained in 8.6) by the desired ratio (e.g. as determined by previous gravimetric comparison runs).
- 8.8 Shut off MINIRAM, reposition and secure battery pack, and re-zero instrument as usual. All subsequent concentration readings are now corrected by the desired ratio.

If an optional Reference Scatterer (MIE model PDM-RS) is available, insert it in the MINIRAM instead of the normal sensing chamber and follow the same procedure (i.e., follow steps 8.1 through 8.8).

## 9.0 ANALOG RECORDER CONNECTION

The analog output of the MINIRAM is a negative voltage of 0 to 1.5 V. A high input impedance recorder (100K $\Omega$ ), or other signal processing device can be connected to that output. The 0 to -1.5V range corresponds approximately to 0 to 100 mg/m<sup>3</sup> as displayed by the MINIRAM.

This analog output (as opposed to the digital output and readings) is not zero-corrected, and thus a zero concentration results in a bias level of the order of several millivolts.

It is advisable to connect a capacitor in parallel with (i.e. across) the analog output (e.g. 100 microfarads or larger) in order to obtain a steady output signal. The internal time constant of the analog output of the MINIRAM is only 0.2 seconds which, in the absence of an external capacitor, results in excessive signal fluctuations.

Two miniature plugs are provided with the instrument to connect to the analog and/or digital output jacks (both can be used concurrently).

## 10.0 USE OF OPTIONAL MIE DIGITAL PRINTER

The MINIRAM can be connected to the MIE model DP-2-80C digital printer, an optional accessory designed for direct coupling to the MINIRAM. This printer can be used both to print out the continuous concentration data (updated every 10 seconds) in the normal measurement mode, and to print out the data stored in the MINIRAM memory as described in section 3.9.

An example of the printout formats when using the printer in combination with the MINIRAM is presented in figure 3. The DP-2-80C, a very compact impact dot matrix printer operates with the MINIRAM using the PDM-DI interconnecting cable connected to the output jack. When using the MINIRAM with this printer, the output data rate should be left at 300 baud (the normal MINIRAM default value), as described in section 4.2.

The following are specific operation procedures for use of the printer in combination with the MINIRAM. Other operating and maintenance information is contained in the instruction manual that accompanies the printer.

### 10.1 Printer Connection

Plug printer cable (MIE model PDM-CB) into the MINIRAM digital output receptacle and press OFF. Turn on the printer power switch (on its right side) and the two green lights on the front will be on if printing paper is in the unit. The ribbon cartridge should have been previously loaded. Refer to the printer User's Manual for details.

## 10.2 Printer Test

In order to test whether the DP-2-80C printer is operating correctly, hold down the LINE FEED button while turning the printer on. Once the printer is on, release the LINE FEED button and the printer will then print out all of its characters. To stop this operation press SELECT.

## 10.3 Printout of Stored Data

Plug printer connector into the MINIRAM digital output receptacle. Turn off printer power switch. Press OFF on MINIRAM and wait until it reads "OFF". Turn on printer power switch. Press PBK on MINIRAM for less than one second (see section 3.9) and the LCD display should then indicate "PA". The printer will then print out the stored data block.

## 10.4 Printout of Zero or of Measurement Data

Interconnect MINIRAM and printer as indicated before and switch on printer power. Press OFF on the MINIRAM. Press either ZERO or MEAS on MINIRAM (depending on which information should be printed out). Printer will print out zero data approximately 72 seconds after pressing ZERO on MINIRAM (see figure 2). The first line of measurement data will be printed out approximately 126 seconds after pressing MEAS, and thereafter every 100 seconds (each line contains ten 10-second measurements). The printer power can be turned off any time during the measurement cycle, and turned on again during a cycle to resume printing. The data line numbers (see figure 3) will then be the current ones as sequenced by the MINIRAM whose output is independent of the operations of the printer.

## 11.0 DIGITAL OUTPUT CONNECTIONS

A digital printer (other than MIE model DP-2-80C), data logger (MIE PDL-10), or modem may be coupled to the MINIRAM. The data output is in the form of 20 mA current loop, 300 baud (110 or 600 baud by alternate programming) asynchronous ASCII characters. The output load should be less than 50 ohms.

Figure 4 is a diagram showing the connections and components required for a 20 mA loop interconnection to a printer. A similar diagram is shown for standard RS232 interfacing with a printer (see Figure 5). These connections do not apply when using the DP-2-80C printer.

The MINIRAM does not send parity information, but does provide an ASCII check sum which is the sum of all ASCII characters, to insure data integrity.

To use the check sum the host computer must add the ASCII value of all digits, spaces, carriage returns, and line feeds except for the first two carriage returns and line feeds which are sent immediately after pressing the PBK switch. The last eight bits of this sum should then be expressed as a decimal number (0-255) and should agree with the decimal value of the MINIRAM check sum.

## 12.0 ROUTINE MAINTENANCE

When the MINIRAM is not being operated it should be placed in its carrying case which should then be closed. This will minimize the amount of particle contamination of the inner surfaces of the sensing chamber.

After prolonged operation within, and exposure to particulate-laden air, the interior walls and the two glass windows of the sensing chamber may have become contaminated with particles. Although repeated updating of the zero reference following the procedure of section 3.10 will correct errors resulting from such particle accumulations, eventually this contamination could affect the accuracy of the measurements as a result of excessive spurious scattering, and significant attenuation to the radiation passing through the glass windows of the sensing chamber.

An indication of excessive chamber contamination is provided by the zero level reading (section 3.10), which should not exceed  $3 \text{ mg/m}^3$ , approximately.

In order to clean a soiled sensing chamber remove that chamber as described in section 7.0 and wash it with soap and water, rinsing thoroughly to remove any residues from the glass windows and interior of the chamber. Do not use solvents of any type. Do not rub interior surfaces of the chamber (coated version). Allow the sensing chamber to dry completely and re-insert into the MINIRAM as indicated in section 6.0.

## 13.0 PRECAUTIONS AND OPERATING POSITIONS

The interior of the MINIRAM sensing chamber should not be exposed to fluctuations of intense light; flashes of sunlight or bright daylight especially, are to be avoided. Such excessive variable illumination of the scattering detector can result in significant measurement errors that may persist over several 10-second display cycles. In order to operate the MINIRAM under those conditions it is advisable to use the Sunshield accessory (MIE model PDM-SNS, see section 16.2).

Another potential source of error is the presence of reflecting surfaces in close proximity to the sensing chamber openings. Such objects should be kept at least 2 cm (3/4 inch) from the chamber openings.

The removable sensing chamber should not be used as a carrying handle, especially not while operating the MINIRAM; holding this chamber may affect the measurements.

When using the MINIRAM for personal monitoring it should be positioned vertically, i.e., with the display/control panel facing upwards, by either clipping the MINIRAM to the belt, shoulder strap, etc.

In general, an approximate vertical position is to be preferred for any long-term monitoring purposes, in that this position minimizes potential particle deposition within the removable sensing chamber.

Other monitoring positions are:

- a) horizontal, resting on belt clip
- b) hand held (while ensuring that hand and fingers are away from the openings of sensing chamber)
- c) Using the optional MINIRAM table stand
- d) Wall mounted using belt clip, or the four battery pack attachment screws on the back of the MINIRAM.

#### 14.0 INTRINSIC SAFETY

The MINIRAM has been designed to satisfy the requirements for intrinsically safe operation in methane-air mixtures. The sealed battery pack incorporates a current-limiting resistor that limits the battery short circuit current to less than 14A. MSHA 2G-3532-0 approval has been granted to the PDM-3.

#### 15.0 SPECIFICATIONS

- Measurement ranges: 0.01 to 10 mg/m<sup>3</sup> and 0.1 to 100 mg/m<sup>3</sup>
- Precision and stability (for 10 sec. readings)\* :  $\pm 0.03$  mg/m<sup>3</sup> (2-sigma)
- Precision and stability of time-averaged measurements\*:  
 $\pm 0.02$  mg/m<sup>3</sup> (for 1 minute averaging)  
 $\pm 0.006$  mg/m<sup>3</sup> (for 10 minute averaging)  
 $\pm 0.003$  mg/m<sup>3</sup> (for 1 hour averaging)  
 $\pm 0.001$  mg/m<sup>3</sup> (for 8 hour averaging)
- Temperature coefficient: 0.005 mg/m<sup>3</sup> per °C (typical)
- Readout resolution: 0.02 mg/m<sup>3</sup> or 0.1 mg/m<sup>3</sup> depending on automatically selected range (3 digit LCD)
- Digital readout updating time: 10 seconds
- Analog output time constant: 0.2 seconds
- Total measurement period: 8 1/3 hours, or indefinite 8 1/3 hour cycles
- Particle size range of maximum response: 0.1 to 10  $\mu$ m in diameter
- Measurement display: normally 10-second real time measurement; or momentarily: time-weighted average, or 8-hour equivalent shift average, or elapsed sample time (in minutes), or zero value, or identification number, or programmable code
- Data storage: seven concentration averages, sampling periods in minutes (3 significant figure resolution), off time (10 minute resolution), identification number, zero value, programmable code, and check sum
- Real time outputs: analog (0 to 1.5V full scale), and digital ASCII

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\* At constant temperature (typ. 25°C)

- Memory playback: either by own LCD display, or by 110, 300 or 600 baud, ASCII digital output (20 mA current loop, or RS232 terminals may be connected with appropriate interface)
- Nominal battery voltage: 7.5V
- Average battery current drain: 40 mA
- Continuous operating time with full battery charge: 10 hours, approximately
- Operating temperature: 0° to 50°C (32 to 120°F) Storage: -20 to 60°C
- Outside dimensions: main body: 10 x 10 x 4 cm (4 x 4 x 2 inches); sensing chamber cover: 7.7 x 3.8 x 1.5 cm (3 x 1.5 x 0.6 inches)
- Weight: 0.45 kg. (16 oz.)

## 16.0 STANDARD ACCESSORIES

Accessories provided with each MINIRAM are detailed in the following subsections.

### 16.1 Battery Charger

The battery charger (MIE model PDM-1-157-1) serves the following functions: recharge or maintain the charge of the nickel-cadmium batteries within the MINIRAM, permit continuous a.c. power line operation, and provide power for the operation of pump of the optional MIE model PDM-1FZ Zero Check Module (see section 17.2). The charger cannot be used to power the MINIRAM without its batteries, however, it can be used to charge a separate or spare battery pack (MIE model PDM-1-101-1, see section 7.0). The output of the MINIRAM battery charger is a low voltage a.c. which is converted to d.c. within the MINIRAM.

The standard battery charger is designed for a 120V/60 Hz input, however, it can be obtained for 220V/50 Hz if so specified.

### 16.2 Sunshield (MIE model PDM-SNS)

The sunshield accessory serves to protect the MINIRAM sensing elements from excessive ambient light fluctuations (see section 13.0). It should be used whenever the MINIRAM is to be operated outdoors or under fluctuating bright light illumination. It is also advisable to use the sunshield to prevent loose clothing or other objects from touching or entering the open sensing chamber. The use of the sunshield causes only a slight retardation of the air exchange rate between the outside and inside of the sensing chamber, an effect that is negligible except when using the analog output in order to follow rapid fluctuations of particle concentration. The sunshield attaches by its two support tabs to the body of the MINIRAM. The sunshield is included with units ordered after April 1987. It is advisable to use the MINIRAM with the sun shield attached at all times, if possible.

### 16.3 Z-Bag™ Calibrator

The Z-Bag™ is a convenient kit for zeroing the MINIRAM in the field. It provides a clean-air environment inside a plastic bag into which the MINIRAM is placed for zeroing. The Z-Bag kit consists of a one-way flow rubber bulb for manual air pumping, a filter cartridge, a zippered plastic container, and connecting hardware.

To use Z-Bag for zeroing MINIRAM proceed as follows:

1. Remove rubber bulb filter assembly from Z-Bag. Place Z-Bag on flat surface with red flow fitting facing up. Flatten bag. Remove small plastic cap from flow fitting on bag.
2. Insert ribbed elbow connector (attached to filter cartridge) into red flow fitting of plastic bag, until connector is flush with bottom of red flow fitting.
3. MINIRAM should be in its OFF condition (observe display). If display is blanked, or if MINIRAM is in the MEAS mode, key OFF.
4. Open Z-Bag and place MINIRAM inside, approximately at its center.
5. Key ZERO through the open end of the Z-Bag. Immediately zip closed the Z-Bag and begin to pump hand bulb.
6. Z-Bag should inflate as hand pumping continues, up to a height of about five inches (12 cm). Continue pumping gently to maintain bag interior pressure, until the MINIRAM displays OFF again.
7. Unzip Z-Bag and remove MINIRAM. MINIRAM is now ready for monitoring.
8. Place rubber bulb/filter assembly inside Z-Bag, and plug small plastic cap into flow fitting to close it. Zip close while flattening Z-Bag to store it to ensure cleanliness of the bag interior.

**CAUTION:** Do not expose Z-Bag to sub-zero freezing temperatures as the plastic zippered bag may crack.

### 16.4 Carrying Case (MIE model PDM-HC)

The PDM-HC is a convenient and compact hard shell carrying case designed to house a MINIRAM and a battery charger. The inside is foam padded for full protection. The outside dimensions of the PDM-HC-1 are: length - 9 1/2 inches, depth - 7 inches, and height - 3 1/2 inches.

### 16.5 Other Standard Accessories

Other accessories supplied with the MINIRAM are:

- Output connectors (can be used for the analog, and/or the digital output jacks)
- Hexagonal wrenches for flow accessories
- Instruction Manual

## 17.0 OPTIONAL ACCESSORIES

Several optional accessories are available from MIE for the MINIRAM, these are described in the following subsections.

### 17.1 Flow Adapter (MIE model PDM-1F)

The Flow Adapter when used in conjunction with the MINIRAM and any pump or external flow system, allows a sample to be drawn through the instrument sensing chamber. A personal monitoring pump at flow rates of 2 l/minute or less may be used.

To attach the Flow Adapter to the MINIRAM loosen the two thumbscrews and pull the front sealing plate forward. Slide the Adapter over the MINIRAM sensing chamber as illustrated above; secure the Adapter to the MINIRAM by tightening the two allen-head screws through the hold down tabs. Tighten the thumbscrews to seal the two end plates to the MINIRAM sensing chamber.

Typically, this accessory would be used when extracting samples from aerosol chambers, detecting leaks from pressurized ducting, or for isokinetic sampling using probes.

### 17.2 Zero Check Module (MIE model PDM-1FZ)

The Zero Check Module can be used to zero the MINIRAM when a clean air environment is not available. The Zero Check Module should be used when concentrations in the range above  $0.5 \text{ mg/m}^3$  are to be measured (see section 3.10).

In addition, this accessory can be used to draw a sample stream through the MINIRAM sensing chamber (in lieu of a separate pump) by disconnecting the small tube at the sensing chamber inlet fitting.

This accessory consists of a pump, filter and the necessary tubing to circulate clean filtered air through the MINIRAM. The pump may be powered by the MINIRAM battery charger (or a 5-10 VDC power supply). The battery within the MINIRAM cannot be used to operate the Zero Check Module.

To zero the MINIRAM, first attach the Zero Check Module following the same procedure described for attaching the basic Flow Adapter (see section 17.1). Connect the battery charger to the Zero Check Module and to an A.C. source. Allow at least one minute of operation to purge the sample chamber with clean air. Press the ZERO button on the MINIRAM and continue operating the Zero Check Module until the final average zero reading is displayed (see section 3.10).

#### NOTES:

When using any of the optional accessories that are attached on and around the sensing chamber (models PDM-1F, -1FZ, and -SNS) to perform measurements at concentrations below  $0.5 \text{ mg/m}^3$ , it is advisable to zero check the MINIRAM with the accessory in place.

making sure that its mounting and sealing screws are properly tightened.

Use an external pump or pressurized air source (well filtered) to drive clean air through the sensing chamber to zero the MINIRAM with any of those accessories (except in the case of the Zero Check Module). To zero check the MINIRAM when using the Sunshield place instrument with the attached sunshield in a clean air environment (see Section 3.10), or using the Z-Bag (see Section 16.3).

### 17.3 Personal Sampler Adapter (MIE model PDM-2FS)

This accessory, when used with the MINIRAM and a personal sampling pump, permits active sampling of respirable (cyclone preselected) particles through the instrument sensing chamber and collection on a filter. The aerosol sample is drawn through a 10 mm nylon cyclone (with a 50% cut point at 3.5  $\mu\text{m}$  when operated at 2 l/minute), through the sensing chamber of the MINIRAM, and then collected on a filter located in the cassette/filter holder for subsequent gravimetric or other analysis.

The model PDM-2FS is compatible with a Millipore 37mm disk filter holder no. M000 037 AO.

To attach the Personal Sampler Adapter to the MINIRAM, follow the same procedure as described for attaching the basic Flow Adapter (see Section 17.1). Connect a length of tubing from the exhaust fitting on the filter holder to a personal sampling pump (not provided with the Adapter).

The use of the Personal Sampler Adapter permits concurrent MINIRAM readings and filter collection to facilitate calibration of the MINIRAM for a specific aerosol, or to determine both concentration and chemical composition of the aerosol.

### 17.4 Shoulder Strap (MIE model PDM-SS)

The PDM-SS is a leather strap, worn over the shoulder and across the chest, which attaches to the wearer's belt in front and back. The MINIRAM clipped to the mounting loop in the upper chest area allows exposure measurements close to the breathing zone while still permitting comfort and freedom of movement.

### 17.5 Table Stand (MIE model PDM-TS)

The table stand accessory provides a convenient mounting support for the MINIRAM when it is used for area monitoring. The MINIRAM is simply clipped onto the table stand which holds it in a convenient position.

### 17.6 Dot Matrix Digital Printer (MIE model DP-2-80C)

This printer is supplied with a special interconnecting cable which is plugged into the digital output jack of the MINIRAM. The DP-2-80C is normally provided for 120V/60 Hz operation. Operation with 220V/50 Hz line can be provided upon customer request.

The use of the DP-2-80C in combination with the MINIRAM is described in Section 10.0. A separate instruction manual for the printer is supplied with that unit.

### 17.7 Reference Scatterer (MIE model PDM-RS)

The PDM-RS is a specially modified sensing chamber that includes a diffusing optical filter mounted within the sensing region of the MINIRAM. It is designed to scatter a controlled amount of light from the infrared source to the detector, providing a stable and repeatable reading on the MINIRAM display. The reference scatterer is inserted into the MINIRAM instead of the normal sensing chamber, and the readings are obtained operating in the MEAS mode. If the PDM-RS is ordered from MIE concurrently with a MINIRAM the reference scatterer will be factory marked with the calibration reading to be obtained when inserted into that particular MINIRAM whose serial number will also be shown on the PDM-RS tag. The readings displayed by the MINIRAM when inserting the PDM-RS should be within approximately  $\pm 5\%$  of the value marked on that reference scatterer.\* The readings obtained with the reference scatterer may show a small warm-up drift (i.e. gradual change) during the initial 5 to 10 minutes after pressing MEAS.

If the reference scatterer is ordered separately from the MINIRAM, the user will then determine the calibration reading obtained on the MINIRAM and mark it (together with the MINIRAM serial number) on the PDM-RS tag.

Because of small differences in the optical configuration of each reference scatterer, the readings obtained with a given reference scatterer are unique to a given MINIRAM. The response to a given population of airborne particles, however, is the same for all factory calibrated MINIRAMs, within approximately  $\pm 5\%$ .

### 17.8 Cable (MIE model PDM-CB)

The PDM-CB cable is used to connect the digital output of the MINIRAM with the input of the 80 column digital printer MIE model DP-2-80C.

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\* Prior to the use of the reference scatterer the MINIRAM should be zeroed with a clean standard sensing chamber as described in Section 3.10.

### 17.9 Portable Data Logger (MIE model PDL-10)

This data logger can be used to record, average, peak detect, etc. concentration levels measured by the PDM-3. A separate instruction manual is provided for the PDL-10.

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Figure 1. Main View of MINIRAM

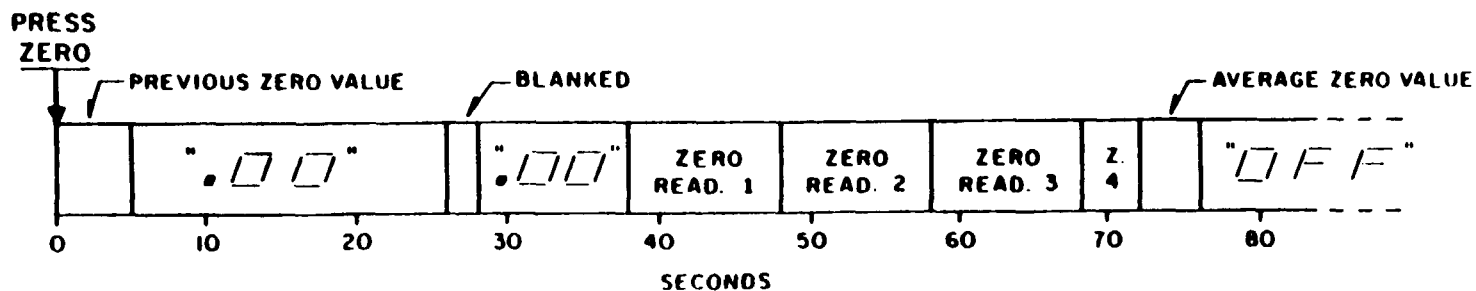
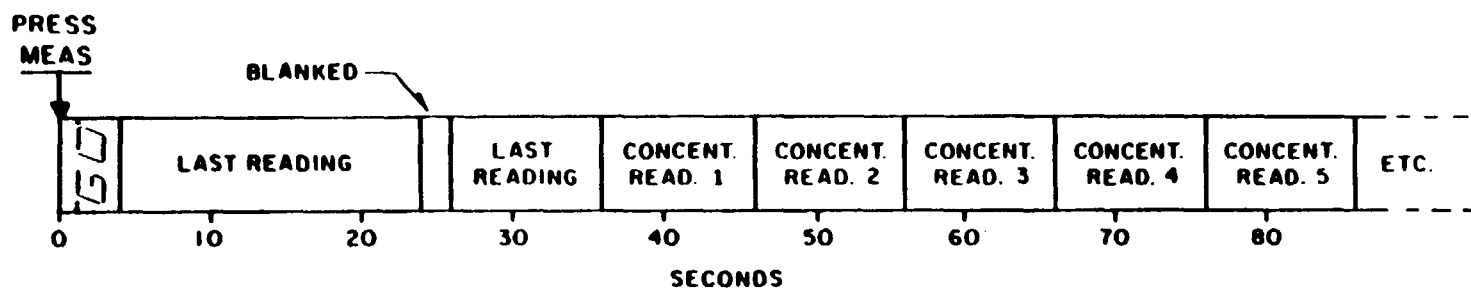
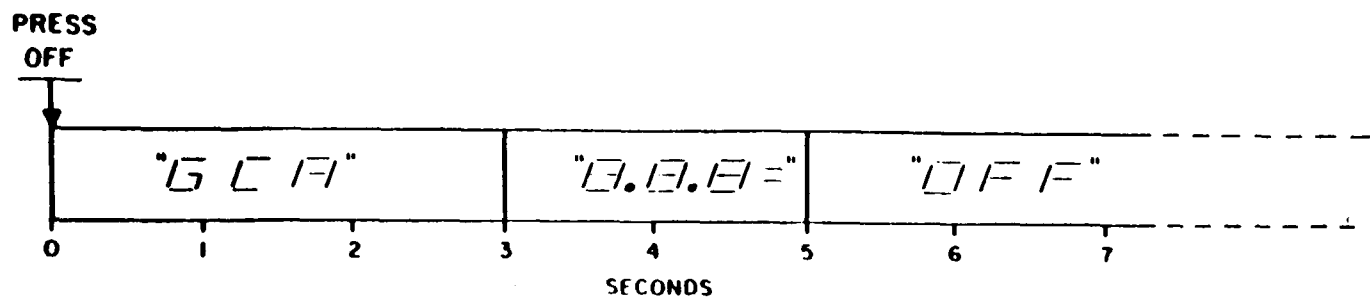


Figure 2. Timing Diagram of MINIRAM model PDM-3 when pressing OFF, MEAS, or ZERO (typical times)

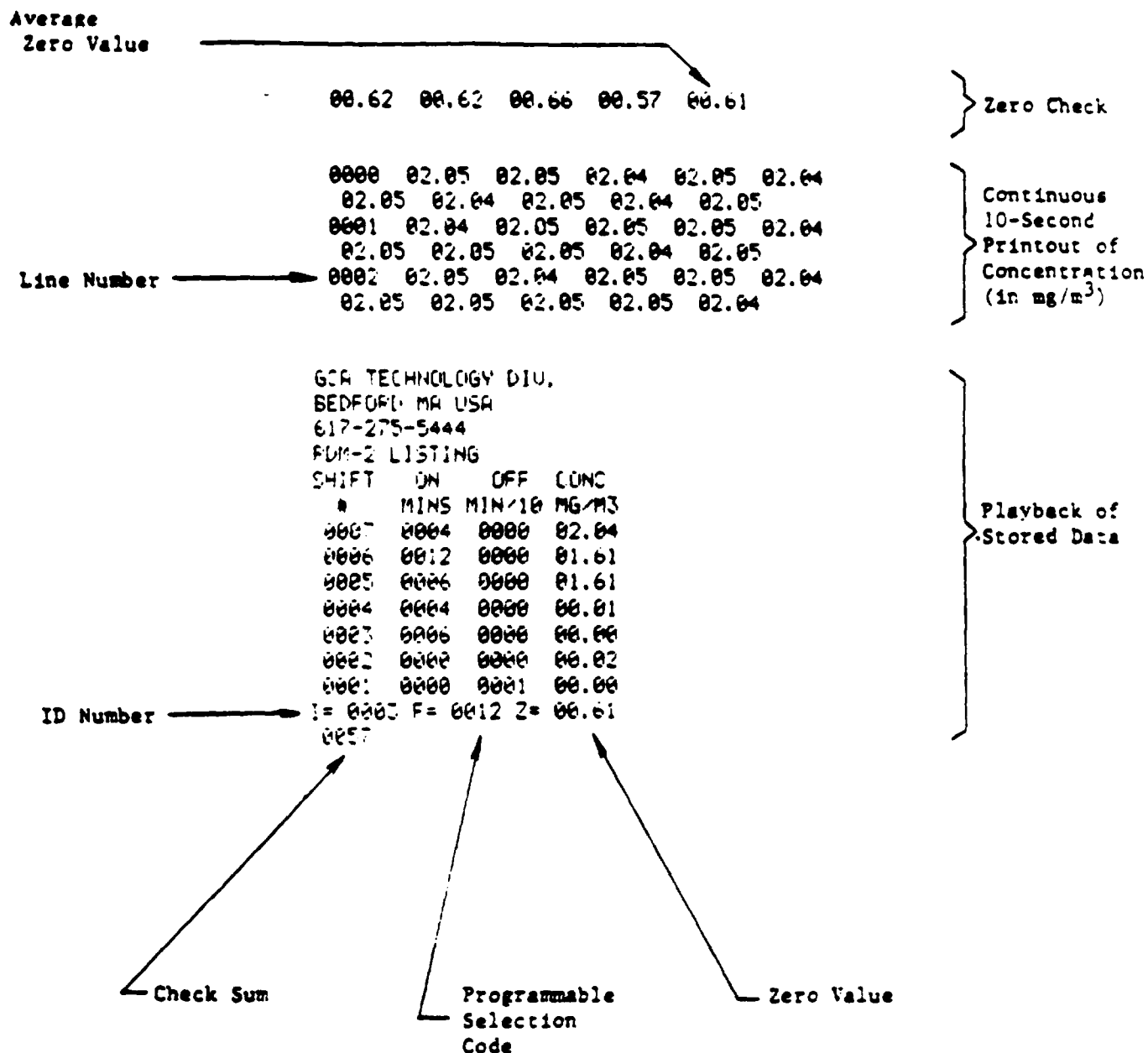


Figure 3. Typical MINIRAM Model PDM-3 Digital Printout Format

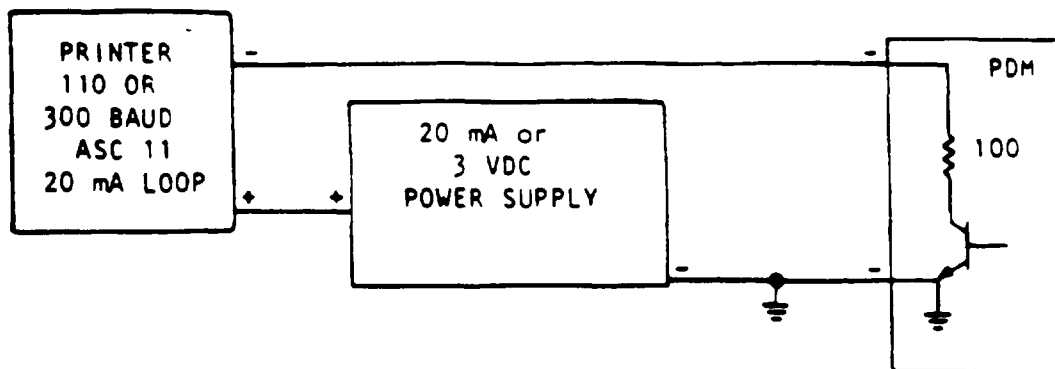


Figure 4. 20 mA Loop Connection

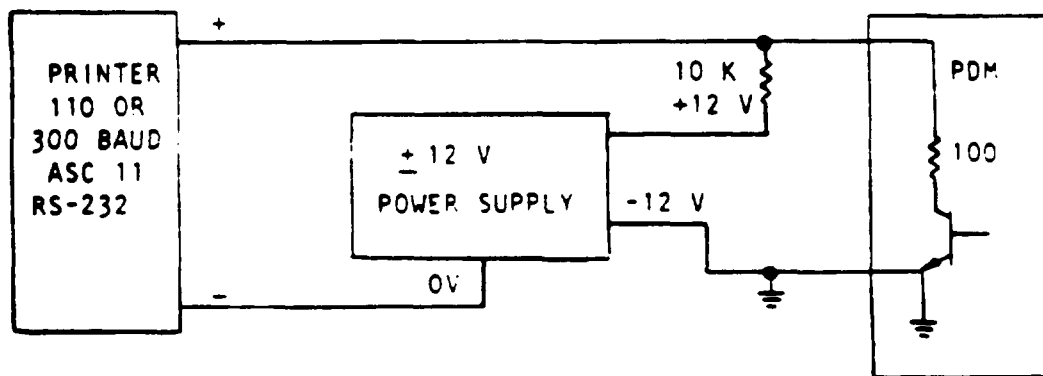


Figure 5. RS-232 Connection